Table 1: Pooled summary estimates describing the diagnostic performance of ^{18}F-FDG-PET/CT, derived from four published meta-analyses, compared to the diagnostic power of MRI in detecting and differentiating (non-)metastatic regional (hilar/mediastinal) lymph nodes in patients with NSCLC on per-patient and per-nodal basis, as stated in present meta-analysis. Sensitivity and specificity are expressed in percentages (%) and accompanied with 95% confidence intervals (square brackets)

	MRI per-patient basis		MRI per-nodal basis	
	Sensitivity (%)	Specificity (%)	Sensitivity (%)	Specificity (%)
Presented meta-analysis	86.5 [77.6-92.3]	88.2 [77.3-94.3]	87.9 [78.2-93.7]	94.7 [86.9-98.0]

	PET/CT per-patient basis		PET/CT per-nodal basis	
Meta-analyses	Sensitivity (%)	Specificity (%)	Sensitivity (%)	Specificity (%)
Lv YL. *et al*, 2011	76 [65-84]	88 [82-92]	65 [62-68]	95 [94-95]
Zhao L. *et al*, 2012	72 [68-75]	90 [88-91]	61 [58-64]	93 [92-93]
Wu Y. *et al*, 2013	72 [65-78]*	91 [86-94]*	78 [64-87]	90 [84-94]
Wu LM. *et al*, 2012	75 [68-81]	89 [85-91]	-	-

[*] Mediastinal lymph nodes only

Conclusions: This meta-analysis demonstrates Level-II evidence of the high diagnostic performance of MRI in staging hilar/mediastinal LNs in NSCLC on both per-patient and per-nodal basis. Relative to FDG-PET/CT, pulmonary MRI is able to reach higher sensitivity at similar specificity, encouraging future prospective studies on treatment decision-making and selective nodal irradiation in NSCLC. However, before pulmonary MRI can replace FDG-PET/CT in NSCLC radiotherapy, thorough assessment of geometric distortion in MR images is mandatory.

PD-0466

Range Probe: a technique to detect patient misalignments

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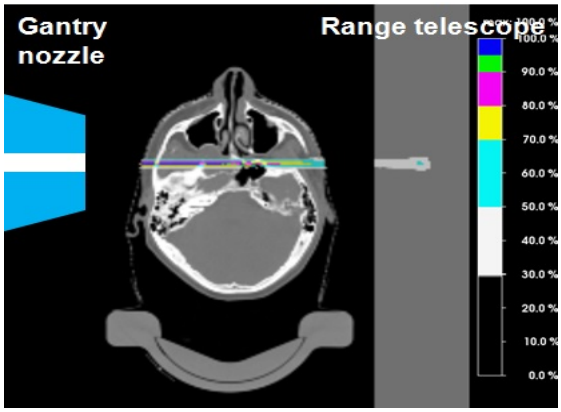
Purpose/Objective: The advantage of proton therapy is the presence of a sharp distal dose fall-off that can be used to spare normal tissues beyond the end of the delivered field. However, due to this sharp fall-off, even small errors resulting from patient misalignments could potentially result in a significant discrepancy between the planned and the delivered dose. Therefore, to tap the full potential of proton therapy, accurate and on-line methods to verify the patient positioning and the proton range during the treatment are desirable. Here we propose and validate a fast and innovative technique for determining shift and rotational positional uncertainties for proton therapy using what we call 'range probes'. A range probe is a narrow, high energy proton pencil beam that shoots through the patient and can be detected on exit and for which the residual range and shape of the Bragg peaks (BP) can be measured using a multi-layer-ionisation-chamber (MLIC) (see Figure 1). By the use of a number of carefully selected range probe positions, the ranges of the detected BP's can uniquely define the orientation of the patient.

Materials and Methods: To validate this approach, an anthropomorphic phantom has been used, and a planning CT acquired. From this, 700 new CT's were generated, assuming different rotations along each axis. Five low dose range probes with energy 177 MeV were then simulated to pass through all these CT data sets using the VMCPro Monte Carlo code, with the residual BP's of each range probe being stored in a database to which experimentally measured range probe BP's can be compared. The phantom was then placed on a rotation device and three new CT's with randomly generated rotations were acquired, representing three possible daily positioning's of the patient. To determine these 'daily' rotational positioning errors, range probes were simulated through these 'daily' CT data sets, and the results compared to the pre-calculated data base, from which the actual 'daily' rotational error could be determined.



Results: In Table 1 the comparison between the predicted rotations and the daily errors are reported for the three studied cases**.** The calculation performed shows that a rotational positioning errors of the phantom can be detected with a resolution of about d_{error}=1°.

Actual rotational error (randomly determined)	Predicted rotational error using 5 range probes	I Deviation I
0°; 0°; +1.8°	0°; 0°; +2.0°	0°; 0°; 0.2°
+1.4°; -1.8°; 0°	+2.0°;-2.0°; 0°	0.6°; 0.2°; 0°
-1.4°; -2.1°; -1.4°	-2.0°;-1.0°; -1.0°	0.6°; 1.1°; 0.4°

Conclusions: With this phantom study we have demonstrated the possible use of a small number of proton range probes for detecting on-line, residual rotational misalignments of patients with a high level of accuracy. The technique is fast and can effectively reconstruct three-dimensional positioning errors from a single proton beam angle.
Even if further investigations and measurements are required before the method can be applied in clinical routine, our simulations and measurements have shown the feasibility of the approach.

PD-0467

Adaptive, preoperative radiotherapy with image guided Tomotherapy concomitant with chemotherapy in rectal cancer

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Purpose/Objective: To report the clinical results of a five years experience in the neo-adjuvant treatment of rectal cancer within a moderate hypofractionated regimen (18

fractions) Adaptive Radiotherapy (ART) approach delivering a concomitant boost to the MRI-based residual tumour during the last 6 fractions.

Materials and Methods: T3/T4N0 or N+ rectal adenocarcinoma patients (pts) were enrolled in an observational trial. Concomitant chemotherapy consisted of Oxaliplatin 100mg/m^2 on days -14, 0, +14, and 5-FU 200mg/m^2/day from day -14 to the end of radiotherapy (day 0 is the start of radiotherapy). Radiotherapy consisted in the delivery of 41.4Gy in 18 fractions (fr) (2.3 Gy/fr) with Tomotherapy to the tumor and regional lymph-nodes (PTV) defined on CT/MRI imaging. After 9 fr, CT and MRI were repeated for the planning of the adaptive phase: PTV_{adapt} was generated by adding a 5mm margin to the residual tumour visible on MRI images. In the last 6 fr, a boost of 3.0 Gy/fr (total dose: 45.6 Gy in 18 fr) was delivered to PTV_{adapt} while concomitantly delivering 2.3 Gy/fr to PTV outside PTV_{adapt}. Data regarding acute toxicity and outcome were analyzed.

Results: From September 2009 to April 2014, 50 pts completed the preoperative treatment and were evaluable. No G4 toxicity occurred: the G3 toxicity was gastrointestinal only: diarrhoea in 9/50 pts (18%), and proctitis in 2/50 (4%). Diarrhoea started before the adaptive phase in all cases and all affected patients were women. Two pts achieved complete response (cCR) and refused surgery, 1 pt was lost, 1 pt had early distant progression. Forty-six pts underwent surgery (43 R0, 3 R1): thirteen pts (28 %) had pathological complete response (pCR); 22/46 (47%) showed TRG3 response: 13/46 (28%) and 6/46 (13%) had ≤5%, and 6-10% residual viable cells, respectively. Regarding the two patients with cCR who refused surgery, one is still cCR after 54 months while the other had local relapse and underwent transanal resection 1 year after treatment. Concerning treatment feasibility, two pts interrupted radiotherapy after 7 and 13 fr respectively, the remaining pts (48/50=96%) completed the treatment, and the median duration of RT was 25 days (22-36 days). 43/50 pts (86%) and 40/50 pts (80%) received the full dose of oxaliplatin and FU, respectively: 14% of pts received moderately reduced doses (60%-90%), and only two pts (4%) received less than 60% of the planned dose.

Conclusions: This study confirms that adaptive boost strategy is feasible with an acceptable G3 toxicity rate and a very encouraging tumour response rate. The results suggest that there should still be room for further dose escalation with the aim of increasing pCR and/or cCR rates.

PD-0468

The practical use of our 1,5 Tesla MRI/HDR treatment room for patients with cervical cancer

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Purpose/Objective: In 2011, we build a dedicated Brachytherapy (BT) treatment suite, equipped with an HDR afterloader and a 1.5 T MR scanner. In this study, we evaluated in which way the MR scanner influences the position verification of applicator and organs at risk (OAR) and induces adaptive interventions during the process of brachytherapy for cervical cancer patients.

Materials and Methods: We collected the data from 16 patients (32 applications), treated with the MR compatible Utrecht tandem/ovoid intracavitary/interstitial applicator (Elekta Brachytherapy, The Netherlands) during the last year. The brachytherapy treatment schedule consisted of two applications and delivery of two HDR fractions each (7 Gy/fr). Applicator insertion, repeated MR imaging and HDR dose delivery were performed in our treatment room equipped with a 1.5 T MRI scanner and a conventional afterloader (Elekta Brachytherapy, The Netherlands). Multiple MR scans during the process of BT were taken (see table). For this analysis we evaluated how often we actually performed direct adaptive interventions aiming at the reduction of uncertainties in dose delivery. Before the first applicator placement, MR images were taken to evaluate tumor extension and the need for needles. If needles were used, short sequence MR scans could be taken directly after the insertion to verify applicator and needle placement and allow adaptation before taking the definitive scans for treatment planning. Prior to dose delivery, MR scanning was repeated for position verification of the applicator parts in relation to the tumor and in order to detect anatomical changes of the OAR's. Adaptive interventions included repositioning of interstitial needles, insertion of rectal tubes to deflate gas or to change the position of the rectum, and variations in bladder filling mainly to reduce bowel dose.

Application 1		Application 2	
BT1	BT2	BT3	BT4
MRpreApp before applicator placement			
MRndl *1min scan if necessary*		*MRndl*	
MRplan for treatment planning		MRplan	
MRprerad before irradiation	MRprerad	MRprerad	MRprerad

ıble: overview of MR scans taken

Results: In 18 of 25 applications with interstitial needles short sequence MR scans were taken to check needle position resulting in repositioning in 3 cases. In 10 of the 16 patients we did interventions with respect to the OAR's, 4 times for bladder and 7 times for rectum. Moreover, we better learned to individualize the use of rectal probes and bladder fillings: One year ago we left the rectal probe in place during irradiation but we discovered it not only deflated gas but also could displace the rectum position. In some cases it brought the rectum closer into the high dose areas. This resulted in a change of procedure. Nowadays we usually insert the probe for deflation and then remove it before scanning and irradiation.

Conclusions: Having a combined 1,5 T MRI/HDR treatment room makes it possible to perform position verifications and adaptive interventions that helps to reduce uncertainties in brachytherapy and to deliver the prescribed dose as accurate as possible according to plan.

PD-0469

Robustness study on pitch and roll rotations for multiple cranial metastases using VMAT

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Purpose/Objective: Volumetric modulated arc therapy (VMAT) was demonstrated to be feasible for radiosurgical treatment of multiple cranial metastases (MCM). The pitch and roll inclusions of 107 brain patients treated in our institute on the PerfectPitch™ 6 degrees of freedom couch revealed 65.5% and 31.8% had pitch and/or roll compensations greater than 1° and 2°. We have investigated the dosimetric consequences of inaccurate pitch and roll